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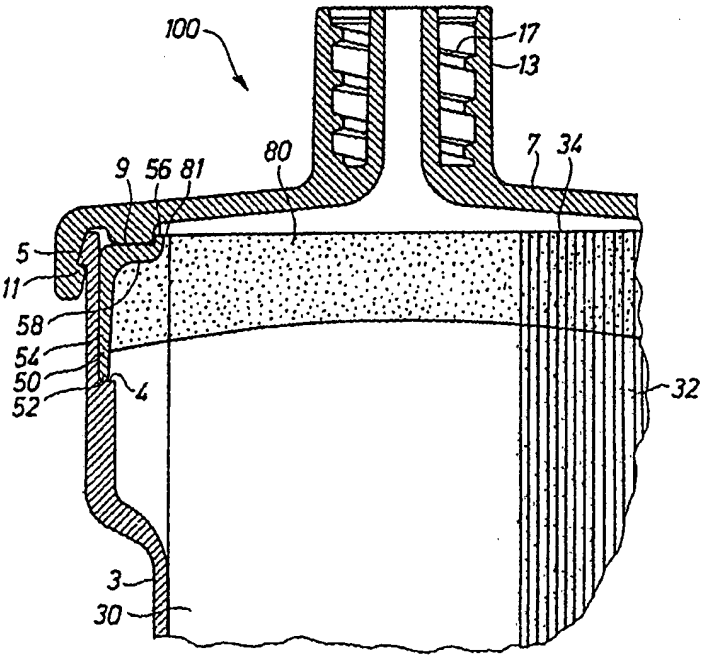
(54) Title: FILTER WITH MEMBRANES OF HOLLOW FIBRES

(57) Abstract

A filter with membranes of hollow fibres (32) is described, wherein the hollow fibres (32) are arranged as a bundle (30) in a tubular housing (3). The housing (3) comprises a cap (7) at each of its ends, while the hollow fibre bundle (30) is disposed between the ends of the housing (3), the ends (34) of the hollow fibre bundle (30) are each surrunded by a support ring (50) and are potted in the support ring (50). The support ring (50) is formed such that the end (34) of the hollow fibre bundle (30) lies with its edge essentially against the support ring (50), and the cap (7) sits axially on the support ring (50). In this way, the ring (81) of potting compound (80) between the edge of the hollow fibre bundle (30) and the support ring (50) or the inner side of the cap (7) is minimised so that the deposition of substances in this region is prevented. Furthermore, the support ring (50) is arranged to be movable in the housing in order to compensate particularly for axial shrinkage of the hollow fibre bundle (30) during heat sterilisation.



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FILTER WITH MEMBRANES OF HOLLOW FIBRES

The present invention concerns a filter with membranes of hollow fibres, wherein the hollow fibres are arranged as a bundle in a tubular housing. The housing comprises a cap at each end, while the hollow fibre bundle is arranged between the ends of the housing, the ends of the hollow fibre bundle each comprise a surrounding support ring and are potted within the ends of the housing, and the hollow fibres terminate with open ends.

TECHNICAL BACKGROUND

Filters with membranes made of hollow fibres are employed for the most diverse purposes in the field of dialysis. For example, filters of this kind are used for haemodialysis, wherein blood is fed through the interior of the hollow fibres formed with semi-permeable walls, and dialysis fluid is passed over the outside of the hollow fibres. During this, various convection and diffusion processes occur through the walls of the hollow fibres, which bring about the cleansing of the blood and the removal of superfluous fluid. Furthermore, the electrolytic concentration in the blood is conditioned and buffers, such as bicarbonate or acetate, for example, are added to the blood.

Similarly, filters of this kind are utilised for so-called haemofiltration, wherein a substitution fluid is added to the blood. The blood is fed through the interior of the hollow fibres, although no dialysis fluid is passed across the exterior of the hollow fibres. In this case, in the filter, superfluous fluid, in particular water, and waste products are removed from the blood merely with the aid of a pressure difference across the membrane, i.e. the semi-permeable wall of the hollow fibres. The substitution fluid can be added to the blood either before the filter or after the filter.

The above-mentioned filters can also be used for generating the substitution fluid itself; they are then called ultrafilters. In this case, dialysis fluid, for example, is fed through the interior of the hollow fibres and filtered through the membrane or semi-permeable walls by means of a pressure difference across the latter, by means of which the dialysis fluid is filtered sterile by the removal of bacteria and endotoxins as well as other contamination products.

Further utilisation possibilities for the above-mentioned filters are, for example, haemodiafiltration, a combination of haemodialysis and haemofiltration, and plasmapheresis, in which the aqueous blood plasma is filtered out of the blood and then fed back into the blood after treatment. However such filters may also be used for reverse osmosis.

The said filters are usually formed in such way that the hollow fibres are bound together as a loose bundle arranged in a tubular housing. The housing comprises a cap at each end, while the hollow fibre bundle is arranged between the ends of the housing so that the caps cover the respective ends of the fibre bundle. The ends of the hollow fibre bundle furthermore comprise a support ring that surrounds them, and are potted in the ends of the housing by means of a potting compound.

The potting compound forms a ring of up to 3 mm thick between the edge of the hollow fibre bundle and the inner side of the cap. This wide ring of potting compound is necessary for several reasons. For example, individual hollow fibres that protrude beyond the cross-section of the hollow fibre bundle must not be covered by the cap or an annular seal between the cap and housing. Also adhesive used to glue the cap to the housing must not penetrate into the hollow fibres at the edge of the hollow fibre bundle and close these.

In both cases, fluid would remain in the sealed or covered hollow fibre after use of the filter. This is critical particularly when, for example, the filter is employed as a haemodialysis filter, a haemofilter or a haemodiafilter,

wherein blood is passed through the interior of the hollow fibres. The blood would then not flow directly into hollow fibres that are sealed at one end, although during the treatment it will be slowly sucked into the hollow fibre as a result of the pressure difference across the hollow fibre membrane. In the mentioned applications, the filter is rinsed after the treatment with a saline solution to completely flush out blood remaining in the hollow fibres. However, when the hollow fibres are sealed or covered at one end, the blood located in the fibres cannot be flushed out, so that blood residue remains in these hollow fibres.

Blood remains, however, are to be avoided, inter alia on the grounds of contamination danger; over and above this the patient has the subjective feeling that a large amount of blood is not returned, event when only a very small amount of blood actually remains in the thin hollow fibre. For these reasons, therefore, the hollow fibre bundle is arranged with a "safety gap" to the inner side of the cap by forming a wide ring of potting compound.

The hollow fibres bound in a hollow fibre bundle each terminate with open ends in the cavity formed between the cap and the end of the hollow fibre bundle. In this way it is possible by arranging suitable inlets and outlets in a known manner to provide diverse filter types, such as the mentioned haemodialysis filter, haemofilter, haemodiafilter, ultrafilter, etc.

Examples of the mentioned filters are disclosed in EP 0 305 687, EP 0 355 325 and EP 0 525 317.

Fundamentally it is common to the mentioned filters that a first fluid is fed through the interior of the semi-permeable hollow fibres, and a second fluid is located outside the hollow fibres. This second fluid can either be passed via suitable inlets and outlets through the housing and past the hollow fibres, or it can be extracted from the first fluid, for example, by a pressure difference across the hollow fibre membrane, and passed out of the housing through a suitable outlet.

A disadvantage of the mentioned filters, for example in the filter disclosed in EP 0 525 317, is that the region above the ring of the potting compound, between the edge of the hollow fibre bundle and the inner side of the cap, cannot be traversed by the first fluid, and is therefore a "dead" region in fluid mechanical terms. This is disadvantageous particularly when the first fluid is blood, such as with the mentioned haemodialysis filters, haemofilters or haemodiafilters, for example. In this case, blood remains in this region above the ring of potting compound, between the edge of the hollow fibre bundle and the inner side of the cap, because the saline solution used to rinse the filter cannot flush the blood out of this region. However, this wide ring of blood or blood residue is to be avoided inter alia for the reasons mentioned above.

The fact that blood landing in this region remains there and can clot there due to the substantially stationary flow is dangerous. This blood clotting can progress until larger blood clots are formed that can lead to a serious endangerment of the patient if they should arrive back in the blood circulation.

DESCRIPTION OF THE INVENTION

In view of this background it is therefore an object of the present invention to provide a filter with membranes of hollow fibres, wherein the hollow fibres are arranged as a bundle in a tubular housing, and the housing comprises a cap at each end, while the hollow fibre bundle is arranged between the ends of the housing, the ends of the hollow fibre bundle each comprise a surrounding support ring and are potted in the ends of the housing, and the hollow fibres terminate with open ends, in which the danger of the first fluid, in particular blood, remaining in the region between the edge of the hollow fibre bundle and the inner side of the cap is avoided.

This object is achieved with a filter of the described kind wherein the end of the hollow fibre bundle lies with its edge essentially at the support ring,

and the cap sits on the support ring.

In this way a filter is provided in which the ring made of potting compound between the edge of the hollow fibre bundle and the inner side of the cap is reduced to a minimum. The end of the hollow fibre bundle, or its end face, lies essentially at the support ring, which means that only a required minimum amount of potting compound is present between the edge of the hollow fibre bundle and the inner side of the support ring, which is necessary for sealing between the hollow fibre bundle and the support ring. Since furthermore the cap sits on the support ring, which means that it is supported only axially, the mentioned edge region between the edge of the hollow fibre bundle and the inner side of the cap is minimised to such an extent, or even eliminated altogether, that a fluid mechanical dead region is no longer present.

The hollow fibres of the hollow fibre bundle that now essentially abut the support ring and terminate with open ends in the cavity between hollow fibre bundle and cap, cause the fluid to flow also through the edge region between the hollow fibre bundle and support ring or cap. It is therefore no longer possible for fluid, for example blood, to remain in the said edge region. If, for example, after the treatment of blood, blood remains in the hollow fibre bundle and in the edge region between hollow fibre bundle and support ring or cap, this can be fully flushed away, also from the said edge region, using a saline solution, as the fluid now also flows through this mentioned edge region.

Advantageously, the hollow fibre bundle terminates level with the support ring. The support ring can also extend a little beyond the hollow fibre bundle, however it is disadvantageous when the hollow fibre bundle extends beyond the support ring. In this latter case it is possible that individual hollow fibres protrude above the hollow fibre bundle, so that the hollow fibre bundle no longer has an exact cross-section. The hollow fibres protruding from the cross-section could then be covered by the cap or be sealed by adhesive, as

mentioned above, with the disadvantages similarly described above.

The support ring can be formed in any desired way, provided that it can surround the hollow fibre bundle at its end, and there at its edge, and provided the cap can sit on it axially. However, it is advantageous when the support ring comprises a first region with a larger diameter and a second region with a smaller diameter, and a circular shoulder between first and second regions, in accordance with a preferred embodiment.

In this way, on the one hand, the support ring can advantageously lie with the first region against the housing, while the end of the hollow fibre bundle can lie in the second region with its edge essentially abutting the support ring. Besides providing a safe binding of the hollow fibre bundle, this enables its secure attachment in the housing. In addition, the exact cross-section of the hollow fibre bundle at its end region is ensured, so that no individual hollow fibre protrudes beyond the cross-section. As described in detail, this guarantees the minimisation of the edge region between the edge of the hollow fibre bundle and the inner side of the cap.

When the second region is formed with a thin wall, and the cap sits on the circular shoulder, in accordance with another preferred embodiment, the secure axial seating of the cap on the support ring is also ensured. With the axial seating of the cap on the circular shoulder, the further advantage is obtained that when, for example, the cap is adhered to the support ring, no adhesive can emerge from the adhesion area and land in the open ends of the hollow fibres. This is prevented by the second region disposed between the adhesion area, i.e. the circular shoulder, and the end face of the hollow fibre bundle.

The thin-walled construction of the second region of the support ring has the advantage that the cap seated axially on the circular shoulder can be arranged at a smaller distance from the edge of the hollow fibre bundle, so that the said edge region between the edge of the hollow fibre bundle and the inner

side of the cap can be further reduced.

Advantageously, the end of the hollow fibre bundle is potted in the support ring with a potting compound, so that the potting compound is only inside the support ring. In this way, the hollow fibre bundle is coupled only to the support ring, but not to the housing, so that the hollow fibre bundle with the support ring is mobile inside the housing at least to a small extent.

When, in accordance with a preferred embodiment, the support ring comprises axially extending bosses that are preferably disposed on the side of the support ring opposing the housing middle, the bosses preferably being flexible, then the support ring is in particular axially movable. Flexible is to be understood here as meaning that the bosses can be compressed or bent over. When for example a corresponding pressing force is then applied in the axial direction to the support ring, the bosses, which for example abut a correspondingly constructed housing protrusion, will be compressed or bent over, and the support ring will be moved axially in the direction of the pressing force until it abuts the housing protrusions again with other parts or areas.

This offers the further essential advantage that axial shrinkage of the hollow fibre bundle, such as occurs particularly during heat sterilisation of synthetic hollow fibres for example, can be compensated for. To this end, the entire hollow fibre bundle is compressed during fabrication of the filter so that the potted ends of the hollow fibre bundle are displaced towards one another by a few millimetres. This has the effect that the individual hollow fibres in the hollow fibre bundle, or the housing, lie relatively loosely, in a similar manner to a loosely composed bundle of threads. The hollow fibres that are each fixed at the ends by the potting compound can therefore retract axially by a certain amount and thus compensate for axial shrinkage, without suffering damage or being torn apart. If, for example, with a corresponding construction of the flexible bosses the hollow fibre bundle is compressed at each end by only two millimetres, i.e. towards the housing centre, a total compensation for the

hollow fibres of up to 4 millimetres is possible.

The axially projecting flexible bosses can naturally also have other dimensions, and, for example, be formed longer so that a greater compression of the hollow fibre bundle is possible by applying a force to the support ring. During this, the axially projecting bosses are bent over or compressed and in this way enable a movement of the support ring and thus of the potted end of the hollow fibre bundle in the axial direction, i.e. relative to the filter housing.

It should be mentioned at this point, even though this is probably unnecessary, that a compression of the hollow fibre bundle is only possible when each end is potted in the support ring. At the same time, the potting compound may also only be inside the support ring to prevent connection of the support ring with the housing. Any suitable material can be used for the potting compound, such as polyurethane (PUR) for example.

To seal the filter or the housing, the cap can be connected in a sealed fashion to the support ring, or the cap can be connected in a sealed fashion to the support ring and the housing. Finally, it is also possible to connect the cap only with the housing in a sealed fashion. The embodiment to be chosen depends on the chosen structural composition of the filter. The sealed connection of the parts is advantageously achieved by adhesion or welding, or also by means of a seal between parts. Possibilities are, for example, elastic annular seals or the like.

The sealed connection between the housing and the first region of the support ring, that is necessary for providing a seal between the region with the first fluid and the region with the second fluid, can be accomplished by adhesion, welding, or by means of appropriate seals, such as O-rings.

In an advantageous embodiment, the support ring is, for example, adhered together with the respective cap to the housing. An adhesive substance is applied to the shoulder of the support ring, and the end cap subsequently put on, so that the adhesive substance is pressed between the first region of the

support ring and the housing and connects these in a sealed fashion.

It is to be noted at this point that the mentioned axial mobility and a certain radial mobility of the support ring, i.e. its movement relative to the housing, is provided only until the support ring is glued or welded to the cap and/or housing. Only by using separate seals does a certain relative mobility of the support ring and therefore the hollow fibre bundle remain in the finished filter.

Finally, according to a preferred embodiment, the filter advantageously comprises an inlet and an outlet for a first fluid, and at least an outlet for a second fluid. Preferably, the inlet for the first fluid is arranged on one cap and the outlet for the first fluid arranged on the other cap so that the first fluid can be fed into the housing, in a simple manner, through the hollow fibre bundle and brought out of the housing again at the other side. The outlet for the second fluid can be arranged on a cap or on the housing, depending on the proposed application of the filter.

According to a further preferred embodiment, the filter comprises an inlet for the second fluid that is preferably arranged either on a cap or on the housing.

DESCRIPTION OF THE DRAWINGS

The invention will be described in more detail below by means of a preferred embodiment with reference to the enclosed drawings. These show in

Fig. 1 a partial sectional view of a filter according to the prior art;

Fig. 1A an enlarged detail of Fig. 1 showing the end of the hollow fibre bundle with the support ring in longitudinal section;

Fig. 2 a longitudinal section through half of a filter according to the invention;

Fig. 3 an enlarged detail of Fig. 2 showing the end of the hollow fibre bundle with the support ring;

Fig. 4 a longitudinal section through a single support ring.;

Fig. 5 a longitudinal section through half of the filter with attached potting lid and potted filter end;

Fig. 6 a longitudinal section through a filter, wherein the end of the hollow fibre bundle has been cut; and

Fig. 7 a longitudinal section through half of a filter wherein the hollow fibre bundle has been axially compressed.

DETAILED DESCRIPTION OF THE DRAWINGS

In Fig. 1 a prior art filter 1 is shown in partial longitudinal section. The filter 1 comprises a tubular filter housing 3 with a cap 7 set on each end. The caps 7 each comprise an inlet 13 and outlet 15 respectively for a first fluid, each of which is provided with an internal screw thread 17. The caps 7 also each comprise an inlet 19 and outlet 21 respectively for a second fluid, each of which is provided with an external screw thread 23. A hollow fibre bundle 30 is arranged inside the tubular housing 3 and extends between the ends of the housing 3. The ends 34 of the hollow fibre bundle 30 are surrounded by a support ring 40 and potted in the ends of the housing 3 by means of a potting compound 80.

The operation of the filter 1 is as follows. Connection conduits for a first fluid are attached to the inlet 13 and outlet 15 by means of the internal screw thread 17 provided there. Similarly, connecting conduits for a second fluid are attached to the inlet 19 and outlet 21 by means of the external screw thread 23 provided there. Subsequently, a first fluid is passed through the inlet 13 to the end 34 of the hollow fibre bundle 30. The hollow fibres 32 arranged in the hollow fibre bundle 30 terminate at this end 34 with open ends so that

the first fluid can be passed through the interior of the hollow fibres 32 to the other side of the filter 1. There, the first fluid exits from the end 34 of the hollow fibre bundle 30 and is drained through the outlet 15.

A second fluid is passed through the inlet 19 in the housing 3, flows along the outer side of the hollow fibres 32 in the hollow fibre bundle 30 to the other end of the housing 3, and is there drained through the outlet 21.

The first fluid and second fluid are guided past one another in counter-flow on different sides of the hollow fibre membrane 32, while diverse convection and diffusion processes occur through the walls of the hollow fibres 32 in a known manner.

In Fig. 1A is shown an enlarged detail from Fig. 1 showing the end 34 of the hollow fibre bundle 30. At its end region, the hollow fibre bundle 30 is encircled by a support ring 40 that comprises a first portion 42 and a second portion 46. The first portion 42 comprises several radial webs 44, with which it abuts the housing 3. The webs 44 are arranged such that they support the support ring 40 both axially and radially. The encircling first portion 42 also comprises several radial webs 48, with which it is connected to the second encircling portion 46. The second portion 46 surrounds the hollow fibre bundle 30 at its end region. This end region of the hollow fibre bundle 30 is potted into the end of the housing 3 together with the support ring 40 by means of a potting compound 80. The second portion 46 of the support ring 40 is completely enclosed by the potting compound 80.

The cap 7 is placed on the housing 3 and attached there by means of an adhesive 82. At the same time, the cap 7 is connected in a sealed fashion to the potting compound 80 by means of the adhesive 82, and lies radially against the outer side of the first portion 42 of the support ring 40.

A ring 81 of potting compound 80 between the edge of the hollow fibre bundle 30 and the inner side of the cap 7 is formed wide. In this way, any penetration of adhesive 82 into the hollow fibres 32, which terminate with

open ends at the end 34 of the hollow fibre bundle 30, is prevented.

It is clear from Fig. 1A that the adhesive 82 is spaced at a sufficient distance from the end 34 of the hollow fibre bundle 30, even when some runs out of the adhesion area between the cap 7 and the potting compound 80. At the same time, it is also apparent that an area is provided above the ring 81 of potting compound 80 through which the first fluid will not flow, and that forms a dead region in fluid mechanical terms. As described in detail above, this relatively large region through which nothing flows is disadvantageous, since, blood, for example, may build-up here with the disadvantages that were similarly extensively described.

A filter 100 according to the invention is shown in longitudinal section in Fig. 2, where for the sake of clarity only one half is shown and like parts are denoted by like reference numerals. The filter 100 comprises a tubular housing 3 on each end of which is arranged a cap 7, one of which is shown here. The cap 7 comprises an inlet 13 with an internal screw thread 17. The housing 3 also comprises an outlet 21 for a second fluid, and an external screw thread 23 is arranged on the outlet 21. A hollow fibre bundle 30 with hollow fibres 32 is arranged inside the tubular housing 3. The end 34 of the hollow fibre bundle 30 is potted in a support ring 50 by means of a potting compound 80. At one end the support ring 50 has several bosses 52, which will be described in detail in the following description of the support ring 50.

It is to be noted at this point that the inlets and outlets may also be arranged differently, as is well known to the skilled person. For example, the outlet 21 can also be arranged on the cap 7.

Fig. 3 shows an enlarged detail from Fig. 2 showing the end 34 of the hollow fibre bundle 30 potted in the support ring 50. Here also, like parts are denoted by like reference numerals.

The support ring 50 comprises a first axial annular portion 54, on which the axially extending bosses 52 are arranged and with which the support ring

50 abuts the housing 3. The bosses 52 are seated on an annular shoulder 4 that is formed to encircle the inner side of the housing 3. The support ring 50 also comprises a second axial annular portion 56 that is connected with the first portion 54 by an annular radial shoulder 58. The hollow fibres 32 of the hollow fibre bundle 30 lie essentially against the second portion 56. Only a thin ring 81 of potting compound 80 is provided between the edge of the hollow fibre bundle 30 and the second portion 56 of the support ring 50.

The second portion 56 of the support ring 50 is formed with thin walls, and the cap 7 sits with a protrusion 9 on the shoulder 58. The cap 7 further comprises clamping means 11 that co-operate with clamping means 5 disposed on the housing 3 and thus attach the cap 7 to the housing 3. Other connection possibilities between the cap 7 and the housing 3 are conceivable in place of the clamping connection illustrated here, such as for example screw attachment, adhesion or welding.

The cap 7 is glued to the shoulder 58 of the support ring 50 at the protrusion 9. Here also other possibilities for forming a sealed connection between the cap 7 and the support ring 50 are conceivable, such as the insertion of a flexible annular seal between the protrusion 9 of the cap 7 and the shoulder 58 of the support ring 50, or welding the protrusion 9 to the shoulder 58, for example.

Finally, the support ring 50 is also connected at the first portion 54 with the housing 3 in a sealed fashion by adhesion together with the cap 7 to the housing 3. Here again, other possibilities for forming a sealed connection between the support ring 50 and the housing 3 are conceivable, such as the insertion of an annular seal between the first portion 54 and the housing 3 or welding the first portion 54 to the housing 3, for example.

As clearly shown in Fig. 3, the potting compound 80 is located only in the support ring 50, and only a narrow ring 81 of potting compound 80 is located between the edge of the hollow fibre bundle 30 and the second portion

56 of the support ring 50. Since this second portion 56 is also thin, the inner side of the cap 7 is situated close to the edge of the hollow fibre bundle 30. The result of all this is that the region above the ring 81 of potting compound 80, which as extensively discussed above constitutes a dead region in fluid mechanical terms, is minimised. However, by minimising this region, the flow behaviour of the first fluid is improved such that deposits in this region are substantially avoided or can be flushed away. Thus the formation of a blood ring is also avoided when, for example, blood is passed through the interior of the hollow fibres 32 of the hollow fibre bundle 30 as the first fluid.

In Fig. 4 a support ring 50 is shown prior to its installation in longitudinal section. The support ring 50 comprises a first portion 54 with a large diameter and a second portion 56 with a smaller diameter. The first portion 54 is connected to the second portion 56 by an annular shoulder 58. The support ring 50 comprises an annular clamping means 60 at the upper edge of the second portion 56. The support ring 50 has several axially extending bosses 52 that are flexible, i.e. bendable or compressible, spaced at regular intervals on the lower edge of the first portion 54.

The support ring 50 has several functions, as will be described with reference to the following figures 5, 6 and 7. In these figures also, like parts are denoted by like reference numerals so that a renewed detailed description of the filter 100 can be dispensed with.

Fig. 5 shows a housing 3 in which a hollow fibre bundle 30 has been laid in longitudinal section, only half of which is shown again for the sake of clarity. The state of the housing 3 shown here corresponds to a method step during the fabrication of a filter 100. The hollow fibre bundle 30 with the individual hollow fibres 32 is placed in the housing 3, and a support ring 50 placed on the end of the hollow fibre bundle 30. The support ring 50 lies with its first portion 54 against the housing 3 and is inserted into the housing 3 by such an amount that the axially extending bosses 52 at the lower edge of the

first portion 54 sit on an annular shoulder 4 on the inner wall of the housing 3. The second portion 56 of the support ring 50 extends beyond the housing 3 and surrounds the end portion of the hollow fibre bundle 30.

As can be seen well in Fig. 5, the cross section of the second portion 56 becomes progressively smaller from the inside to the outside, i.e. upwardly in Fig. 5. This has the effect that the outermost end of the hollow fibre bundle 30 lies directly against the second portion 56 of the support ring 50, while the edge region of the hollow fibre bundle 30 that is spaced a little from the end of the hollow fibre bundle 30 is separated by a small distance from the second portion 56 of the support ring 50. In this way an adequate seal is provided between the hollow fibre bundle 30 and the support ring 50 or second portion 56 when the hollow fibre bundle 30 is potted and cut, as described below.

A potting cover 70 is placed on the second portion 56 of the support ring 50. The potting cover 70 comprises clamping means 72 that co-operate with the mentioned clamping means 60 of the support ring 50. In this way, the potting cover 70 is connected firmly and in a sealed fashion to the support ring 50.

The support ring 50 in combination with the potting cover 70 thus serves as a potting mould for the potting compound 80. The latter is fed into the housing 3 through the outlet 21 and pressed towards the end region of the hollow fibre bundle 30, for example by centrifugal force, so that the potting compound 80 is distributed in the support ring 50 as shown. The support ring 50 and the potting cover 70 form the potting mould through their connection by means of the clamping means 60, 72 so that the potting compound 80 cannot pass beyond the support ring 50. As a result, the hollow fibre bundle 30 is connected by the potting compound 80 in a sealed fashion only with the support ring 50 and not with the housing.

After potting the hollow fibre bundle 30, the second portion 56 of the support ring 50 is severed about the line 36. In this way, the ends of the hollow

fibres 32 terminate with open ends. At the same time, by virtue of the mentioned small spacing between the second portion 56 and the edge of the hollow fibre bundle 30 an adequate seal is provided between these two by means of the thin ring 81 of potting compound 80.

This state after the described method step is shown in Fig. 6.

Fig. 6 shows the housing of Fig. 5 after the next method step, while like parts are again denoted by like reference numerals. In this way a renewed detailed description can be dispensed with here also.

After severing the second portion 56 of the support ring 50, the hollow fibres 32 of the hollow fibre bundle 30 terminate at the end 34 of the hollow fibre bundle 30 with open ends. The hollow fibre bundle 30 terminates flush with the support ring 50 or the second portion 56, that is formed with a thin wall and projects somewhat from the annular shoulder 58 of the support ring 50. As extensively described above, only a thin ring 81 of potting compound 80 is present between the second portion 56 of the support ring 50 and the outer edge of the hollow fibre bundle 30.

The support ring 50 sits with its flexibly formed and axially protruding bosses 52 at the lower edge of the first region 54 on an annular shoulder 4 on the inner wall of the housing 3. As the potting compound 80 is located only inside the support ring 50, as described in detail, the support ring 50 is not connected with the housing 3 and can be moved relative to the same.

Beside the given radial movement possibility of the support ring 50, the possibility of axial movement is essential. This, together with the axially protruding and flexibly formed bosses 52, offers the potential to compensate for the shrinking that occurs primarily with synthetic hollow fibres during the heat sterilisation of filters. To this end, the hollow fibre bundle 30 is compressed lengthways, for example by applying a pressing force on the annular shoulder 58 of the support ring 50. The flexible bosses 52 at the lower edge of the support ring 50 are thereby bent over or compressed, and the end

34 of the hollow fibre bundle 30 is slid a little way into the housing 3. As this is performed simultaneously on both sides of the housing 3, the hollow fibres 32 are relaxed by a few millimetres, and thus lie loosely in the hollow fibre bundle 30 or housing 3. This gives them the possibility to compensate for shrinkage of a few millimetres in a problem-free manner without tears or other damage.

Fig. 7 shows this state of the compressed hollow fibre bundle 30. Here again like parts are denoted by like reference numerals so that a renewed detailed description can be dispensed with. It can be clearly seen here that the support ring 50 is pushed somewhat into the housing 3, which brings the mentioned advantages.

As described extensively above, the mobility of the support ring 50 or the hollow fibre bundle 30 relative to the housing 3 is provided until the support ring 50 is glued or welded to the housing 3 and/or the cap 7, that is, essentially during fabrication of filters 100. Only when using seals between the support ring 50 and housing 3 and the cap 7 does the support ring 50 also have a certain mobility even in the finished filter 100.

With the relative mobility of the support ring 50, the compression of the hollow fibre bundle 30 enabled according to a method step later enables the compensation for longitudinal shrinkage of the hollow fibres 32. This longitudinal shrinkage of the hollow fibres 32 is the result of the final heat sterilisation of the finished filter 100 and occurs especially in synthetic hollow fibres.

LIST OF REFERENCE NUMERALS

1	Filter according to the prior art
3	Housing
4	Shoulder
5	Clamping means
7	Cap
9	Boss
11	Clamping means
13	Inlet
15	Outlet
17	Internal thread
19	Inlet
21	Outlet
23	External thread
24	Hollow fibre bundle
32	Hollow fibre
34	Hollow fibre bundle end
36	Section line
40	Support ring according to the prior art
42	First portion
44	Web
46	Second portion
48	Web
50	Support ring
52	Flexible boss
54	First portion
56	Second portion
58	Shoulder
60	Clamping means
70	Potting cover
72	Clamping means
80	Potting compound
81	Ring of potting compound
82	Adhesive
100	Filter

Claims:

1. Filter with membranes of hollow fibres (32), wherein the hollow fibres (32) are arranged as a bundle (30) in a tubular housing (3) and the housing (3) comprises a cap (7) at each of its ends, the hollow fibre bundle (30) being arranged between the ends of the housing (3), the ends (34) of the hollow fibre bundle (30) each being encompassed by a support ring (50) and being potted in the ends of the housing (3), and the hollow fibres (32) terminating with open ends,

characterised in that the end (34) of the hollow fibre bundle (30) lies with its edge essentially against the support ring (50) and the cap (7) sits on the support ring (50).

2. Filter according to claim 1, **characterised in that** the hollow fibre bundle (30) terminates flush with the support ring (50).

3. Filter according to claim 1 of 2, **characterised in that** the support ring (50) comprises a first portion (54) with a larger diameter and a second portion (56) with a smaller diameter, and an annular shoulder (58) between the first and second portions (54, 56).

4. Filter according to claim 3, **characterised in that** the second portion (56) is formed with thin walls and the cap (7) sits on the annular shoulder (58).

5. Filter according to claim 3 or 4, **characterised in that** the end of the hollow fibre bundle (30) lies with its edge essentially against the second portion (56) of the support ring (50).

6. Filter according to claim 3, 4 or 5, **characterised in that** the support ring (50) lies with the first portion (54) against the housing (3).

7. Filter according to one of the previous claims, **characterised in that** the end (34) of the hollow fibre bundle (30) is potted in the support ring (50) with a potting compound (80) in such a way that the potting compound (80) is only inside the support ring (50).

8. Filter according to claim 7, **characterised in that** the support ring (50) comprises axially protruding bosses (52).

9. Filter according to claim 8, **characterised in that** the axially protruding bosses (52) are disposed on the side of the support ring (50) opposing the middle of the housing (3).

10. Filter according to claim 8 or 9, **characterised in that** the bosses (52) are formed to be flexible so that the support ring (50) is axially movable.

11. Filter according to one of the previous claims, **characterised in that** the cap (7) is connected to the support ring (50) in a sealed fashion, or that the cap (7) is connected to the support ring (50) and the housing (3) in a sealed fashion, or that the cap (7) is connected to the housing (3) in a sealed fashion.

12. Filter according to claim 11, **characterised in that** the cap (7) is adhered or welded to the support ring (50), or that the cap (7) is adhered or welded to the support ring (50) and the housing (3), or that the cap (7) is adhered or welded to the housing (3).

13. Filter according to claim 11, **characterised in that** the cap (7) is connected to the support ring (50) in a sealed fashion by means of a seal, or that the cap (7) is connected to the support ring (50) and the housing (3) in a sealed fashion by means of a seal, or that the cap (7) is connected to the housing (3) in a sealed fashion by means of a seal.

14. Filter according to one of the previous claims, **characterised in that** it comprises an inlet (13) and an outlet (14) for a first fluid, and at least an outlet (21) for a second fluid.

15. Filter according to claim 14, **characterised in that** the inlet (13) for the first fluid is disposed on one cap (7) and the outlet (15) for the first fluid is disposed on the other cap (7).

16. Filter according to claim 15, **characterised in that** the outlet (21) for the second fluid is disposed on a cap (7) or on the housing (3).

17. Filter according to one of claims 14 to 16, **characterised in that** it comprises an inlet (19) for the second fluid.

18. Filter according to claim 17, **characterised in that** the inlet (19) for the second fluid is disposed on a cap (7) or on the housing (3).

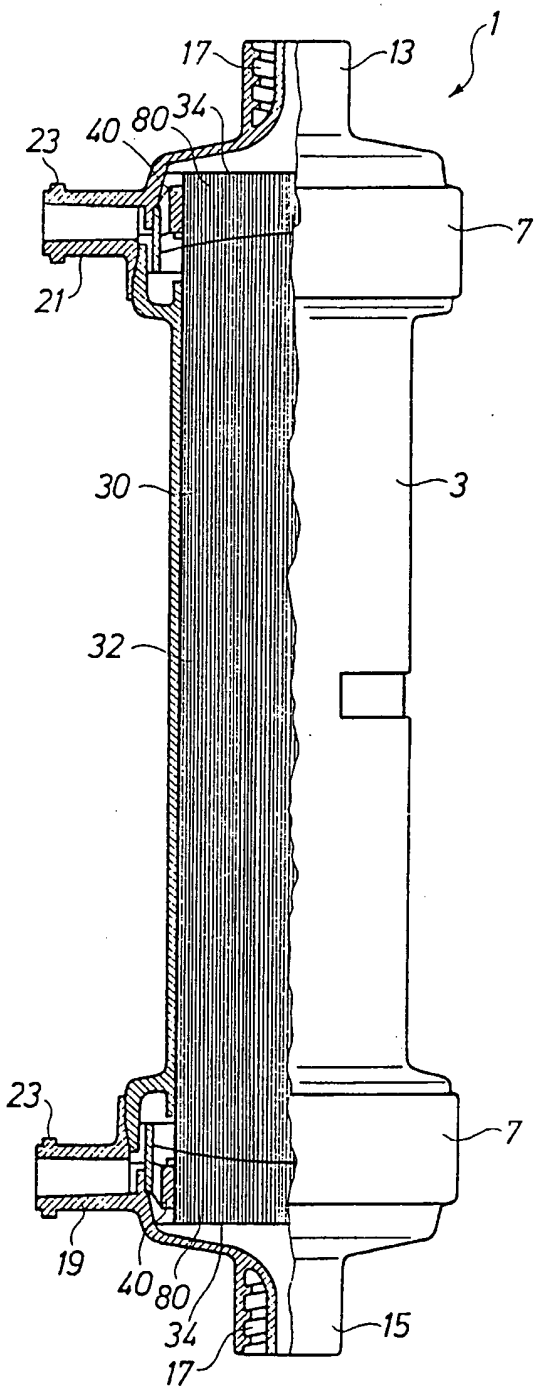


FIG. 1 (prior art)

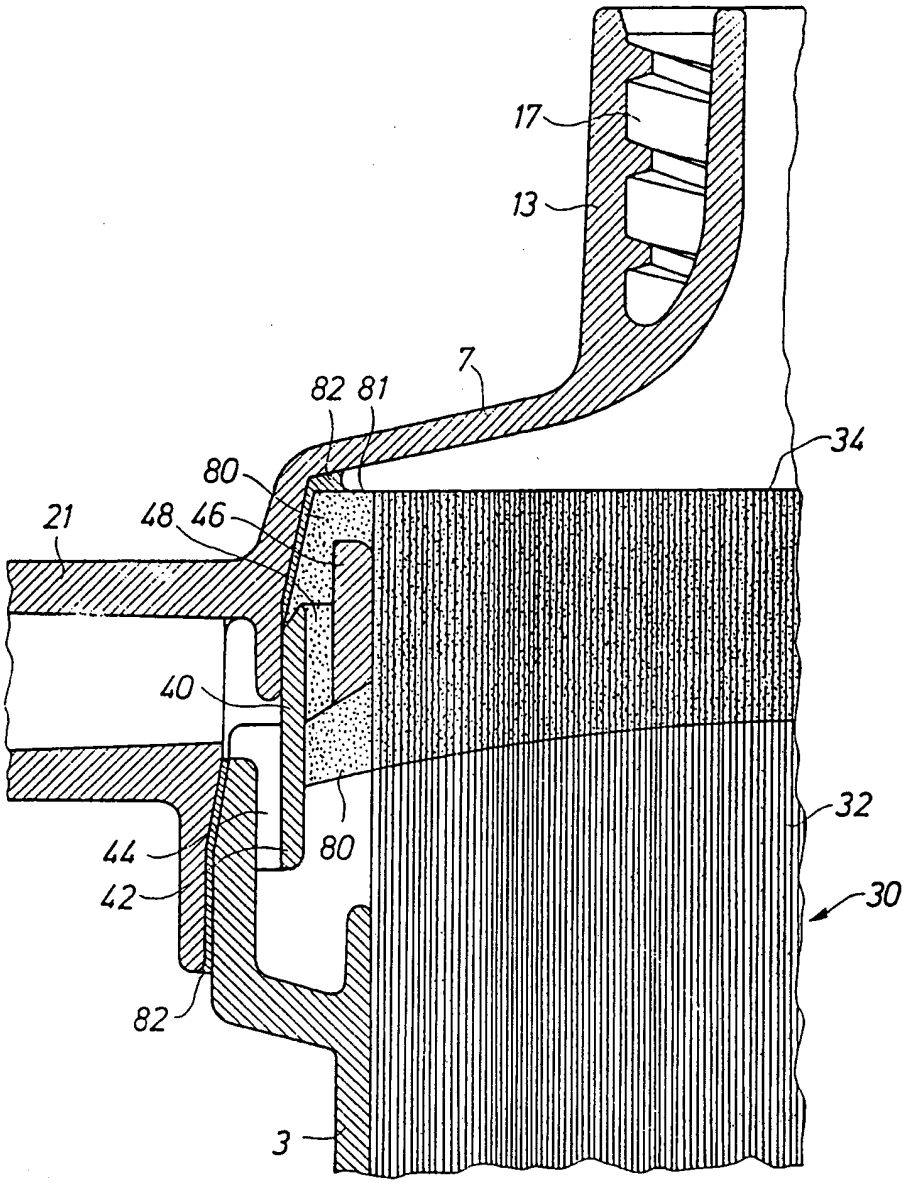
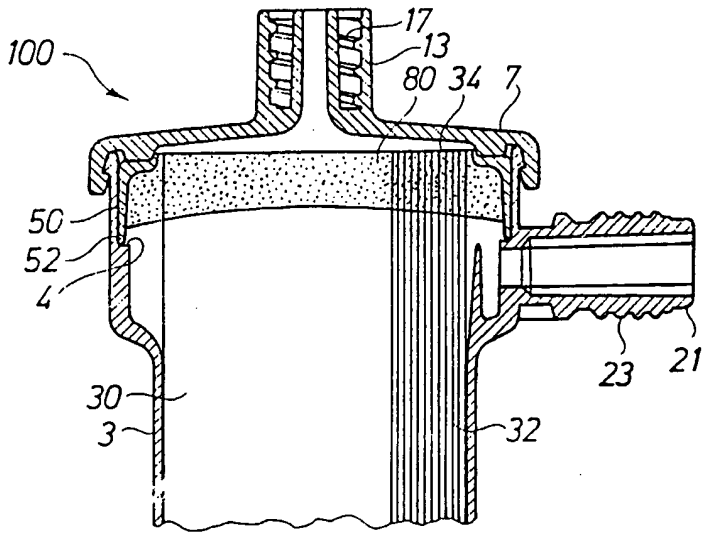


FIG. 1a (prior art)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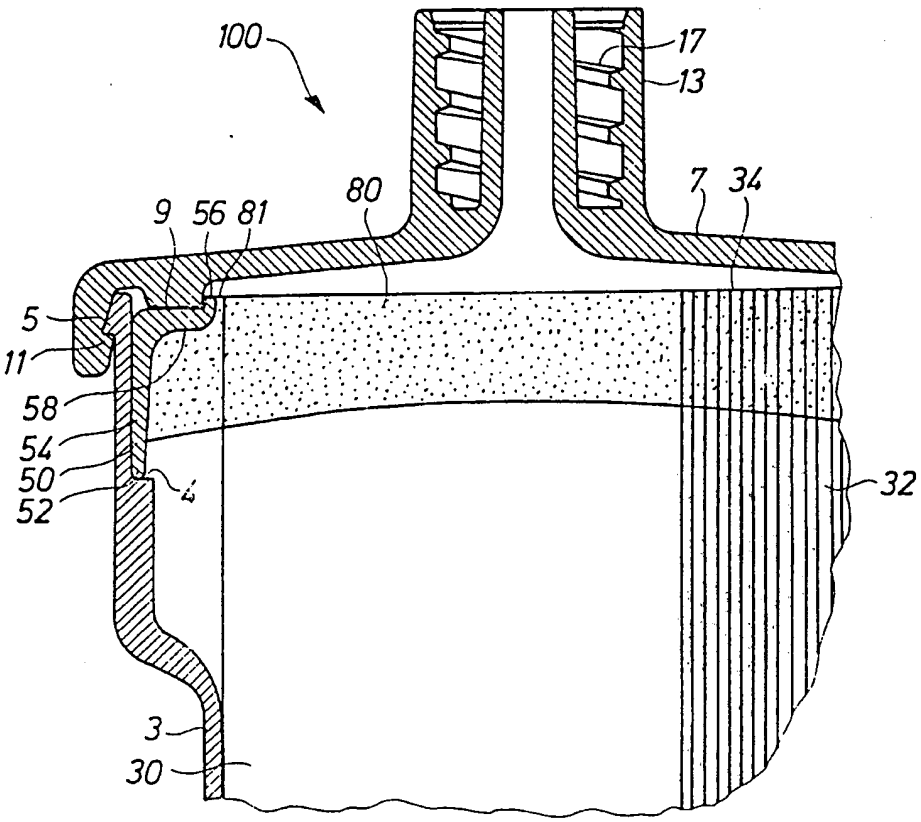
21

FIG. 2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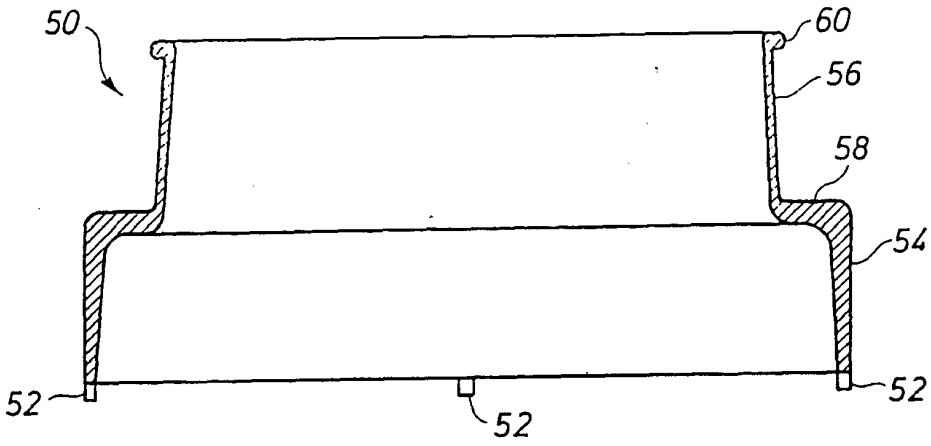
32
3
30

FIG. 3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52
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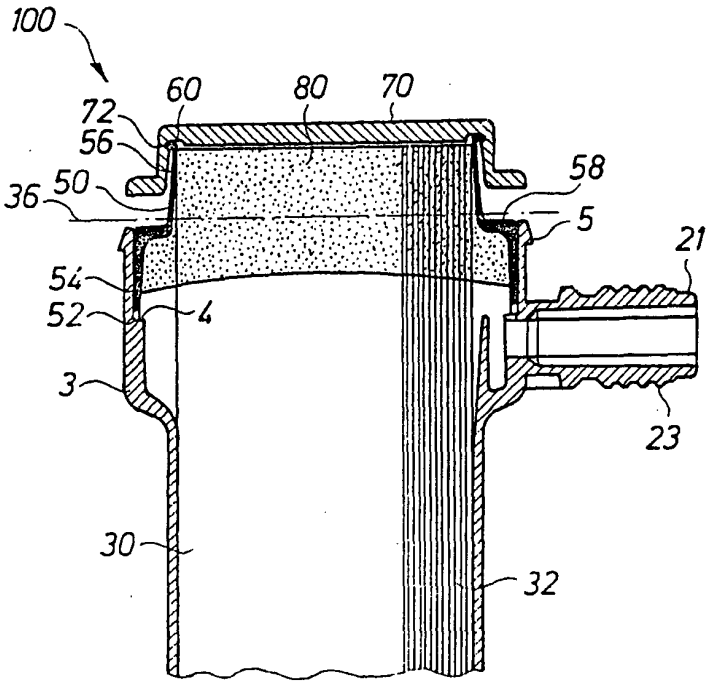
52

FIG. 4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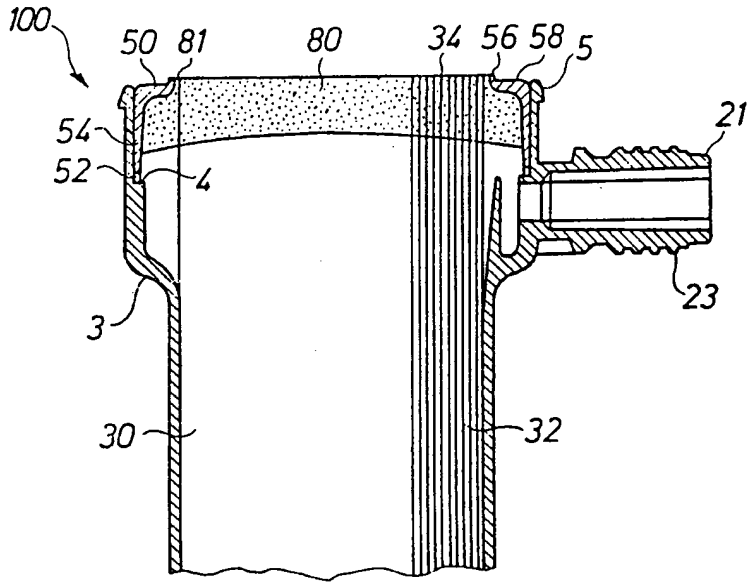
32

FIG. 5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30
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FIG. 6

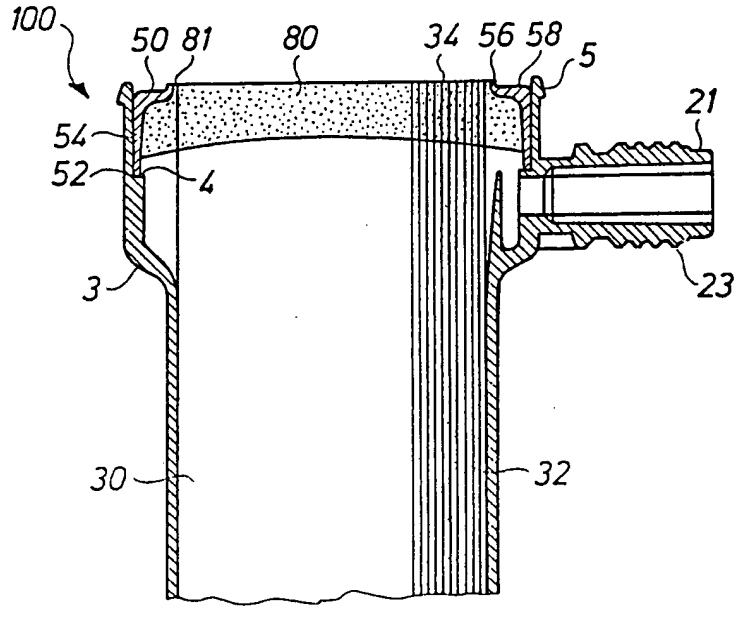
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FIG. 7

INTERNATIONAL SEARCH REPORT

Intern ial Application No
PCT/IB 00/00069

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D63/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 283 284 A (SCHNELL WILLIAM J) 11 August 1981 (1981-08-11) the whole document	1-3,5-7, 11-18
A		4

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 June 2000	28/06/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Hoornaert, P

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Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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A	---	4
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Intern ial Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

Interr nal Application No
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